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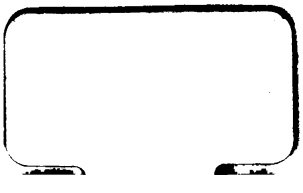

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BEDFORDSHIRE,—sheets 46 (NW, NE, SW†, & SE†), 52 (NW, NE, SW, & SE).
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BUCKINGHAMSHIRE,—7* 13* 45* (NE, SE), 46 (NW, SW†), 52 (SW). Horizontal Sections, 74, 79.
CAERMARTHENSHIRE, 37, 38, 40. 41, 42 (NW & SW), 56 (SW), 57 (SW & SE). Horizontal Sections 2, 3, 4, 7, 8, 9; and Vertical Sections 3, 4, 5, 6, 13, 14.
CAERNARVONSHIRE,—74 (NW), 75, 76, 77 (N), 78, 79 (NW & SW). Horizontal Section 28, 31, 40.
CARDIGANSHIRE,—40, 41, 56 (NW), 57, 58, 59 (SE), 60 (SW). Horizontal Sections 4, 5, 6.
CHESHIRE,—73 (NE & NW), 79 (NE & SE), 80, 81 (NW* & SW*), 88 (SW). Horizontal Sections 18, 43, 44, 60, 64, 65, 67, 70.
CORNWALL,—24† 25†, 26†, 29†, 30†, 31†, 32†, & 33†.
DENBIGH,—73 (NW), 74, 75 (NE), 78 (NE & SE), 79 (NW, SW, & SE), 80 (SW). Horizontal Sections 31, 35, 38, 39, 43, 44, and Vertical Sections, sheet 24.
DERBYSHIRE,—62 (NE), 63 (NW), 71 (NW, SW, & SE), 72 (NE, SE), 81, 82, 88 (SW, SE)). Horizontal Sections 18, 46, 60, 61, 69, 70.
DEVONSHIRE,—20†, 21†, 22†, 23†, 24†. 25†, 26†, & 27†. Horizontal Sections, sheet 19.
† The Geology of the Counties of Cornwall and Devon is fully illustrated by Sir H. De la Beche's "Report." 8vo 14*s.*
DORSETSHIRE—15, 16, 17, 18, 21, 22. Horizontal Sections, sheets 19, 20, 21, 22 56. Vertical sections, sheet 22.
FLINTSHIRE —74 (NE), 79. Horizontal Sections, sheet 43.
GLAMORGANSHIRE,—20, 36, 37, 41, & 42 (SE & SW). Horizontal Sections, sheets 7, 8, 9, 10. 11; and Vertical Sections, sheets 2, 4, 5, 6, 7, 9, 10, 47.
GLOUCESTERSHIRE,—19, 34*, 35, 43 (NE SW & SE), 44*. Horizontal Sections 12, 13, 14, 15, 59; and Vertical Sections, 7, 11, 15, 46, 47, 48, 49, 50, 51.
HAMPSHIRE,—8†, 9, 10*, 11, 12*, 14, 15, 16. Horizontal Section, sheet 80.
HEREFORDSHIRE,—42 (NE & SE), 43, 55, 56 (NE & SE). Horizontal Sections 5, 13, 27, 30, 34; and Vertical Sections sheet 15.
KENT,—1† (SW & SE), 2† 3† 4*, 5, 6†. Horizontal Sections, sheets 77 and 78.
MERIONETHSHIRE,—59 (NE & SE), 60 (NW), 74, 75 (NE & SE). Horizontal Sections, sheets 26, 28, 29, 31, 32, 35, 37, 38, 39.
MIDDLESEX,—1† (NW & SW), 7*, 8†. Horizontal Sections, sheet 79.
MONMOUTHSHIRE,—35, 36, 42 (SE & NE), 43 (SW). Horizontal Sections, sheets 5 and 12; and Vertical Sections, sheets 8, 9, 10, 12.
MONTGOMERYSHIRE,—56 (NW), 59 (NE & SE), 60, 74 (SW & SE). Horizontal Sections, sheets 26, 27 29 30, 32, 34, 35, 36, 38.
NORTHAMPTONSHIRE,—64, 45 (NW & NE), 46 (NW), 52 (NW, NE, & SW) 53 (NE, SW, & SE), 63 (SE), 64.
OXFORDSHIRE,—7*, 13*, 34*, 44*, 45*, 53 (SE*, SW). Horizontal Sections, sheets 71, 72, 81, 82.
PEMBROKESHIRE,—38, 39, 40, 41, 58. Horizontal Sections, sheets 1 and 2; and Vertical Sections, sheets 12 and 13.
RADNORSHIRE,—42 (NW & NE), 56, 60 (SW & SE). Horizontal Sections, sheets 5, 6, 27.
RUTLANDSHIRE,—this county is included in sheet 64.
SHROPSHIRE,—55 (NW, NE), 56 (NE), 60 (NE, SE), 61, 62 (NW), 73 74 (NE, SE). Horizontal Sections, sheets 24, 25, 30, 33, 34, 36, 41, 44, 45, 53, 54, 58; and Vertical Sections, sheets 23, 24.
SOMERSETSHIRE,—18, 19, 20, 21, 27, 35. Horizontal Sections, sheets 15, 16, 17, 20, 21, & 22; and Vertical Sections, sheets 12, 46, 47, 48, 49, 50, and 51.
STAFFORDSHIRE,—(54 NW), 55 (NE), 61 (NE, SE), 62, 63 (NW), 71 (SW), 72, 73 (NE, SE), 81 (SE, SW). Horizontal Sections 18, 23, 24, 25, 41, 42, 45, 49, 54, 57, 51, 60; and Vertical Sections, sheets 16, 17, 18, 19, 20, 21, 23, 26.
SURREY,—1 (SW†), 6†, 7*, 8†, 9. Horizontal Sections, sheets 74, 75, 76, and 79.
SUSSEX,—4*, 5 6, 8, 9, 11. Horizontal Sections, sheets 73, 75, 76, 77, 78.
WARWICKSHIRE,—44*, 45 (NW), 53*, 54, 62 (NE, SW & SE), 63 (NW, SW, & SE). Horizontal Sections, sheets 23, 48, 49, 50, 51 82, 83; and Vertical Sections, sheet 21.
WILTSHIRE,—12*, 13*, 14, 15, 18, 19, 34* and 35. Horizontal Sections, sheets 15 and 59.
WORCESTERSHIRE,—43 (NE), 44*, 54 55, 62 (SW & SE) 61 (SE) Horizontal Sections 13, 23, 25, 50, and 59; and Vertical Section 15.

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82 S.E.

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE

GEOLOGY OF PARTS OF NOTTINGHAMSHIRE AND DERBYSHIRE.

EXPLANATION OF QUARTER SHEET No. 82 S.E. OF THE GEOLOGICAL SURVEY OF ENGLAND AND WALES.

BY

W. TALBOT AVELINE, F.G.S.

SECOND EDITION.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.

LONDON:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE.
AND SOLD BY
LONGMAN & Co., Paternoster Row; TRÜBNER & Co., Ludgate Hill;
LETTS & SON, 33, King William Street;
EDWARD STANFORD, 55, Charing Cross; and J. WYLD, 12, Charing Cross:
ALSO BY
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CONTENTS.

	Page
Notice - - - - - - - - -	5
Introduction. Area. Rivers. Physical aspects. Geological Divisions - - - - - - - -	7
Coal Measures - - - - - - - -	8
Permian Series - - - - - - - -	9
Lower Magnesian Limestone - - - -	„
White Sandstone Quarries of Mansfield - - -	10
Red Sandstone Quarries of Mansfield - - -	11
Magnesian Limestone Quarries of Mansfield Woodhouse -	13
Do. do. do. of Pleasley Vale - - -	14
Do. do. do. of Stony Houghton - -	15
Do. do. do. of Langwith Valley - -	„
Do. do. do. of Bolsover Moor - -	„
Do. do. do. of Creswell Crags - -	16
Summary of Lower Magnesian Limestone - - -	„
Permian Marls and Sandstone - - - -	17
Upper Magnesian Limestone - - - -	18
New Red Sandstone Series or Trias - - - -	19
Keuper:—Waterstones and Red Marl - - -	20
Bunter:—Lower Soft Red and Mottled Sandstone -	„
Pebble Beds and Conglomerate - - -	„
Drift - - - - - - - -	21
Physical Geography - - - - - - -	„

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NOTICE.

THE area described in this Explanation is situated on the S.E. confines of the Yorkshire and Derbyshire Coal-field, and is occupied almost entirely by Permian and Triassic rocks which overlie the Coal-Measures.

The ground was examined in 1857–58 by Mr. Aveline, and the first edition of this Explanation was published in 1861.

The valuable building-stones which occur in the district, and the intimate relations between geological structure and physical features that are here well exhibited, render this tract of country interesting from a scientific, as well as important from a commercial, point of view.

H. W. BRISTOW,
Senior Director.

Geological Survey Office,
28, Jermyn Street, London, S.W.
November 20, 1879.

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THE

GEOLOGY OF PARTS OF NOTTINGHAMSHIRE AND DERBYSHIRE.

EXPLANATION OF GEOLOGICAL MAP, QUARTER SHEET, No. 82 S.E.

THE district which this Map illustrates comprises an area of about 170 square miles, the greater portion of which is in the county of Nottingham; the smaller portion along the western borders being in Derbyshire. In the part belonging to Nottinghamshire are situated the central portion of the ancient forest of Sherwood, and the towns of Mansfield and Ollerton. It contains no rivers of any importance, but several small ones, tributaries of the river Idle, either rise in or flow through the country. The river Maun rises near Sutton-in-Ashfield, a village situated in the south-west part of this district, and, flowing by Mansfield, takes a north-easterly direction across the forest to Ollerton and the river Idle. The river Meden rises beyond the western borders of this district, and entering it a little north of Skegby, flows through Pleasley vale, and crossing the forest in a parallel direction to the river Maun, enters that river near Perlethorpe. The Poulter also runs parallel to the other two rivers, and, passing through the Langwith valley by Cuckney through Clumber Park, enters the Maun near Elksley. All the other brooks join one or other of the above rivers (except a few on the eastern borders that flow south-eastward to the Trent), and all are tributary to the Idle; showing that the drainage of the country is from west to east, and depends upon geological causes.

This area in its physical aspects may be divided into three tracts, an eastern, a central, and a western division, all differing from each other. The eastern division is undulating, with rounded hills not rising more than from 100 to 200 feet above the lowest ground, well watered by many small streams, and having for the most part a rich agricultural soil. The central and largest division is what is known as the Forest-Lands, the soil being either sandy or gravelly, and poor for agricultural purposes; but many fine trees still grow there, remnants of the ancient forest. These forest-lands, as a whole, have a gradual rise from east to west till they attain a considerable elevation, and then descend with a sharp slope to the west; this order being only broken by the rivers that pass through the western escarpment, and by various minor elevations and depressions in the heart of the country. The average height of the country along the eastern borders of the Forest-Lands is about 150 feet above the level of the sea; that of the western escarpment is 400 feet, but the highest point is 634

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feet at a station on Coxmoor, south of Mansfield. The third division lies westward of the Forest-Lands, and this also has a general downward inclination from west to east; but otherwise it is a very uneven country, and the soil is light and in some parts stony. Like the Forest-Land it has an abrupt escarpment to the west, overlooking a district occupied by Coal-measures which physically form a very different country to any of the three previously noticed. Nearly the whole of this escarpment is beyond the western boundaries of our district, and only a small portion of it bending eastward forms some low ground north of Skegby.

The following geological formations in descending order occur in this district:—*

New Red Sandstone, or Triassic series. f.	Keuper	Red Marls and White Sandstone, f^6.
		Waterstones (Porous Sandstones and Marls), f^5.
	Bunter	Pebble and Conglomerate Beds, f^2.
		Lower Soft Red and Mottled Sandstone, f^1.
Permian e.		Upper Magnesian Limestone, e^4.
		Red Marls and Sandstone, e^3.
		Lower Magnesian Limestone, e^2.
Carboniferous d.		Coal-measures, d^5.

These formations, with their divisions and sub-divisions, are shown by colours on the map, and are also marked by a separate letter and number. A thin superficial deposit of drift gravel or sand spread over the country is not indicated on this map. The white lines show the lines of faults or dislocations. The small arrows point to the direction in which the beds are inclined, and the numbers by the side of the arrows denote the amount of the inclination in degrees. The small crosses show where the beds are horizontal.

COAL-MEASURES.

The Coal-measures, which occupy but a very small portion of the surface of this country, occur in the low ground north of Skegby, and are overlooked by the escarpment of the Magnesian Limestone. These Coal-measures are not actually seen at this spot, but there is no doubt they are there, not only on account of the level of the ground and the marshy character of the soil, indicating clays beneath, but fragments of the lowest beds of the Magnesian Limestone are found scattered about the fields on a higher level. These Coal-measures are the eastern extremity of an inlet of the Derbyshire coal-field,† but only some of the highest strata of that field, above all the chief workable coals, are found near the surface at this particular locality.

* A section showing the relative position of these formations is published. See Section 2, Sheet No. 61, of the Geological Survey of England and Wales.

† See Quarter Sheet 82 S.W. of the Geological Survey of England and Wales.

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Though so small a portion of this district is represented on the map as Coal-measures, they extend beneath all the other strata, and may be reached by penetrating those formations. Of course the depth that the Coal-measures lie beneath the surface depends on what part of the county we may be in; for proceeding from west to east the strata accumulate one over another till there is a vast thickness of overlying rocks. Over the country occupied by the Magnesian Limestone the depth to the Coal-measures will be equal to the thickness of that rock, or from 100 to 120 feet; but over some parts of this area the limestone must be exceedingly thin, as, for instance, in Pleasley Vale, and at Stony Houghton, where, for a small space, the limestone is altogether wanting; also near Creswell and other spots which will be more fully pointed out in the description of the Magnesian Limestone. But the finding of the Coal-measures by no means implies the discovery of workable coal. The highest coal of much value in the Derbyshire coal-field is the "Top Hard Coal," and though this bed may not lie very deep near Skegby, the depth must rapidly increase in an easterly and northerly direction; and it is probable that near Creswell the thickness of strata from the top of the Coal-measures to the "Top Hard Coal" cannot be much less than 500 yards.* Any pit commenced on the high grounds of the limestone country would have to pass through a considerable thickness of that hard and compact rock before the Coal-measures are reached, but in many of the valleys the thickness of limestone would be inconsiderable.†

PERMIAN SERIES.‡

It will be seen on referring to the geological table of strata, at p. 8, that there is an Upper and a Lower Magnesian Limestone, divided from each other by marls and sandstone; but the Upper occupies so small a part of this district that in speaking of the Magnesian Limestone I must be understood as referring to the Lower Limestone. Beginning on the south and proceeding northwards I shall now describe the various quarries and other sections.

Lower Magnesian Limestone.

Near Sutton-in-Ashfield there are some large quarries of yellow limestone used for building-stone, road material, and for making into lime. The stone of these consists of both hard and soft beds, varying from a coarse to a fine-grained rock. The higher beds of the series are flaggy. From Sutton-in-Ashfield eastward, across the strike of the limestone, the beds are chiefly of a coarse grain

* The bed of poor coal that is worked between Bolsover and Barlborough would be first reached.

† Since the above was written it has been considered, on good authority, that the Coal-measures do not continue their steep easterly dip but flatten beneath the overlying formations and finally rise with a westerly dip. See Report of the Royal Coal Commission.

‡ For other details respecting this series, not strictly connected with the district, see Sedgwick, "On the Geological Relations and Internal Structure of the Magnesian Limestone," &c., &c., *Trans. Geol. Soc.* ser. 2, vol. iii., page 37.

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and a yellow colour. The dip is eastward not more than 2° which is also about the same as the inclination of the ground, therefore a person walking from the Sutton railway-station to Sutton keeps nearly on the same bed, except when he descends into slight hollows. The thickness of the limestone cannot be more than between thirty and forty feet, but below the limestone there are bands of shale, sandstone, and limestone; and as these beds occur within the area above the Coal-measures north of Skegby (though there is no actual section seen), I will describe them from a section just outside the district. On the road from Skegby, to where the hill has been cut down, a good section of rock is exposed. The highest beds are yellow limestones, getting sandy at their base, and passing downwards into beds of soft sandstone of a brown colour. Interstratified with these sandstones are bands of hard compact limestone containing fossil shells, and the sandstone is full of fossil wood. These beds might be mistaken for Coal-measures, if it were not for the bands of limestone, the fossils found in which are Permian species. There must be about twenty feet of these beds exposed, but their actual junction with the Coal-measures is not seen though it cannot be far below.

The following fossils, determined by Mr. Salter, were found in the limestone-bands:—

Gervillia (*Bakewellia*) *ceratophaga.* Schloth.
Schizodus (*Axinus*) *truncatus.* King.
Pleurophorus costatus. Brown.

And in the sandstone,—

Fragments of Plants, undeterminable.

There is another section of these beds in a road-cutting on Fulwood Top, 2 miles further south; but here there are not so many bands of limestone, and more of the soft brown sandstone, with fragments of fossil wood.

The White Sandstone Quarries of Mansfield.

These extensive quarries are worked on the south side of Mansfield. This rock, which is only a siliceous variety of the Magnesian Limestone, is a white calcareous sandstone, and it is only here that the Magnesian Limestone exists under this form. These beds form a good freestone, and make a most excellent building-stone. The following analysis was made by the late Mr. Richard Phillips, and furnished me by Mr. Charles Lindley, of Mansfield.

Mansfield White Sandstone, with which the Terrace is paved at Trafalgar Square.

Silica	51·40
Carbonate of Lime	26·50
Carbonate of Magnesia	17·98
Iron, Alumina	1·32
Water and loss	2·80
	100·00

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In the quarries, where the above stone is found may be seen a face of between fifty and sixty feet of massive irregular beds of a light-yellow fine-grained sandy limestone, some of the beds of which are separated by thin layers containing greenish sand, and some of the stone is also streaked with green. There are perpendicular joints in these beds, wide apart, and striking north and south; and there is also much false bedding, but the true dip is eastward, at an angle of 3°. The top beds afford the purest limestone of the quarries, and are burnt for lime. It is from the lower parts of the quarry that the white sandstone is obtained, and the bottom of this is not reached owing to the large quantity of water that is met with. This stone besides being used for building and paving, is hollowed into cisterns, troughs, &c.

The Red Sandstone Quarries of Mansfield.

"On the east side of the glen which descends to Mansfield, is a quarry which lays bare a system of beds, about fifty feet thick, of very extraordinary character. The bottom beds are about twenty in number, and vary from less than one foot to three or four feet in thickness; but the planes of separation are extremely irregular, and not continuous. They are of a dull red colour, and might, without close examination, be mistaken for New Red Sandstone. The thin beds are much used in building; and the thickest are hewn out into large troughs and cisterns, and in that state are conveyed into all the neighbouring counties. Over the system just described is a band of clay surmounted by striped slaty ferruginous beds, which gradually pass into a coarse yellow magnesian limestone.

"This red dolomitic sandstone rises and falls in long sweeping undulations, and may be traced to a quarry on the side of the Chesterfield road, where it preserves nearly the same colours and external characters, and is worked for the same purposes.

"In the whole range of the Magnesian Limestone I know of no deposit which can be compared with that which is here described; and it is more remarkable, as it is found in the heart of the formation, and nearly in a line with the finest specimens of crystalline dolomite."*

These deposits, so accurately described by Professor Sedgwick in the above quotation, are another local variety of the Magnesian Limestone; and I believe, though I could get no certain proof, that these beds are the same (altered in colour by an excess of iron and slightly varying in structure) as the white sandstones of Mansfield. They are on the same geological horizon, have the more calcareous beds on the top, and at the bottom of the quarries the same large quantity of water is met with.

The following analysis, also by Mr. Richard Phillips, of stone from Mr. C. Lindley's Rock Valley and Chesterfield Road quarries, will show how completely the two are alike in mineral composition.

* Professor Sedgwick, *Trans. Geol. Soc.* ser. 2, vol. iii., pp. 83, 84.

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Mansfield Red Sandstone, also used in the Terrace at Trafalgar Square, London.

	Colour.	
	Roseate.	Brown.
Silica - - - - -	49·4	49·4
Carbonate of Lime - - -	26·5	26·5
Carbonate of Magnesia - -	16·1	16·1
Iron, Alumina - - - -	3·2	3·2
Water and loss - - - -	4·8	4·8
	100	100

In this valley a face of rock is exposed of nearly seventy feet in depth. The highest beds are good crystalline limestones, of a yellow colour; but as you descend the face of the quarry the beds gradually change, both in composition and colour, from a crystalline limestone to a calcareous sandstone, and from yellow to red. It is about thirty feet from the top where the stone fit for making cisterns commences; and this improves towards the bottom of the quarry, but downward progress is stayed by the water. This sandstone is also an excellent building-stone. Mr. Gilbert Scott calls it "one of the best building-stones in the kingdom." It is also much used as a paving stone.

The same beds are also worked at the freestone quarries on West Hill, by the side of the Chesterfield Road, where a face of rock is exposed of at least sixty feet in depth; and, as in the Rock Valley, the highest beds are yellow limestone, and become more and more siliceous in a downward direction. The beds are raised in the form of an arch or dome. A well was sunk in one of the quarries, and some coarse limestone was found below the sandstone. There is here also a plentiful supply of water at the bottom of the quarries.

On the north side of Debdale Lane another quarry in the same beds has been opened, to a depth of sixty feet, where they find a light-red sandstone at the bottom; and the whole of these strata are clearly below the limestone beds, which occur both to the north and south of the quarry.

These beds are only seen again in Pleasley Vale, where they crop out beneath the limestone. At Pleasley Forge there is about six feet of good red freestone, with some yellow freestone below it. There is also a red freestone-quarry about 650 yards to the north-west of Pleasley Works, where may be seen thick and thin beds of red and yellow calcareous sandstone dipping 2° 20′ N., at an angle of 4°. Some very hard coarse limestone lies below these beds. Red sandstone is again seen in a road-cutting three-quarters of a mile north-east of Pleasley; and the last place where these beds are seen is at the cross-roads half a mile E.N.E. of Stony. Houghton. They are there thrown up in a broken dome-shaped mass.

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Mansfield Woodhouse Limestone Quarries.

In these quarries may be seen a massive but irregularly-bedded and beautifully crystalline limestone of a very fine yellow colour speckled with black. The crystals often radiate from a centre, but in other parts the stone is more amorphous and compact, and is then harder. This rock, from its hardness and composition, forms a most excellent and durable building-stone, as Southwell Cathedral and other old buildings will testify. The foundation and lower part of the Houses of Parliament at Westminster were built with it. The composition is as follows, from the analysis by Mr. Richard Phillips, of the stone from the quarries of Mr. Charles Lindley;

Magnesian Limestone, intended for the New Houses of Parliament.

Carbonate of Lime	51·65
Carbonate of Magnesia	42·60
Silica	3·70
Water and loss	2·5
	100

The above stone was also used for the Martyr's Monument at Oxford. This rock is higher in the series than the red and white calcareous sandstones. Like them, it is rather limited in its range,—that is to say, as regards stone of the same good quality, colour, and crystalline structure; for the only other place where it has been quarried is on Bolsover Moor, where, though like in other respects, it is more irregular in the bedding, and the joints and oblique laminations traversing the stone render it nearly impossible to obtain large blocks. The usual size of the blocks at the Bolsover Moor quarries, when worked into a rough shape, is from 3 feet to 4 feet long, 2 feet broad, and not exceeding 9 inches in thickness; and I only saw one block that measured 7 feet by 3 feet, and from 1 foot to 2 feet in thickness. The stone of the Bolsover Moor quarries was that selected by the Commissioners for the New Houses of Parliament, but it was not used in the building.

On the north-east side of Mansfield Woodhouse there is some hard calcareous rock of a reddish colour,—not the red sandstone, but a coarse-grained limestone, too hard for a freestone, but used for building and paving. These beds appear to be above the yellow limestone.

In Oxclose Lane, west of Mansfield Woodhouse, beds of yellow limestone have an easterly dip of about 2°, and this dip, if the beds were prolonged, would carry them *over* the ridge to the west. At the large limestone quarries on the south-west side of the village, although the beds dip in all directions, they appear, as a mass, to be inclined eastward, and this would take them above the red sandstone of Debdale Lane and West Hill.

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Pleasley Vale.

On the west side of the River Meden, between it and the road leading from Pleasley to Newbound Mill, there are scattered about the ground fragments of the hard and compact greyish-blue fossiliferous limestone that is found banded with shales at the base of the Magnesian Limestone, and these beds may be seen *in situ* in the road above. Although nothing is to be seen in the bed of the river, the occurrence of these bottom beds on its bank would go to prove that the stream must run either on Coal-measures or on beds very close above them.

At Baxter Hill, on the east side of the Meden, there is a quarry of hard fine-grained sandy limestone, yellow, red, and brown, the lower beds being like the red freestone, but not quite so fine in grain or so sandy. These beds have an apparent dip towards the north at an angle of 10°; but there is no dependence to be placed on this dip, for I believe that the beds have slipped down the hill towards the river.

Between Moorhaigh and the river there is some hard coarse yellowish limestone, like that generally found near the bottom of the series.

On the high ground south of Pleasley there are many quarries of fine-grained yellow limestone. The dip of these beds is uncertain, owing to much false bedding; but their inclination is certainly small, so that in ascending the hill we always come upon higher beds.

At Pleasley Church there is a strong spring, and the nearest rock to it is a hard and gritty red and light-yellow limestone, the beds of which are much broken, and have an easterly dip. In a quarry in Netherfield Plantation there is a hard and compact fine crystalline thin-bedded limestone, white and light-yellow in colour, the dip of which is south-easterly at an angle of 15°. Between this place and Pleasley Church the rocks have evidently been disturbed by a fault or dislocation, in the line of which the above-mentioned spring occurs. Some of the beds dip as much as 25° or 30° in an easterly direction.

Between Pleasley Works and Pleasley Forge there are several sections of the rock, the lowest bed exposed being the red sandstone; and there is a good thickness of limestone above. At the Forge there are about six feet of good red freestone, and below this a freestone of a yellow colour. At a spring by the brook side, ten chains north-west of Pleasley Works, there is a bed of rock very like the blue fossiliferous limestone in the shales at the bottom of the Magnesian Limestone series; and I think there can be no doubt that the River Meden runs for some way down Pleasley Vale on very low beds, which also extend up the small valley that enters the vale at Pleasley Works. I have already noticed the red freestone quarry on the east side of that valley, 30 chains north-west of Pleasley Works. There is some red calcareous and sandy freestone on the south side of the river at

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Hind Car, and there is another quarry of more calcareous stone south of Littlewood. A short distance below Hind Car, Pleasley Vale ends, and there are no good sections below. About 12 chains north of Park Farm there is a quarry of yellow-coloured large-grained limestone, with much false bedding.

Stony Houghton.

At Stony Houghton there are quarries of hard and compact limestone, some of the beds of which are quite cherty and as hard as any of the Carboniferous Limestone which it more resembles than the ordinary yellow Magnesian Limestone, and in some of the quarries it is a calcareous breccia. As the same kind of beds occur near the base of the Magnesian Limestone at Bolsover, a village about three miles north-west of Stony Houghton, I have little doubt that this place stands on the basement beds; if, indeed, there is not even a small inlier of Coal-measures. Strong springs are thrown out from under the limestone, and at one spot, west of Houghton, there is the blue fossiliferous limestone, which has been found nowhere except at the base of the Magnesian Limestone. The triangular inclosure coloured on the Map as Coal-measures at Stony Houghton is marshy ground, which either covers Coal-measures or the marls that sometimes lie under the limestone.

The limestone quarries east of Stony Houghton are in thin-bedded hard yellow limestones, the bottom beds of which are red and sandy, dipping N.N.E. 2°. To the north-east of these quarries is the round boss of red freestone, mentioned before; (p. 12).

Langwith Valley.

The river Poulter, running through the Langwith Valley, rises at a small inlier of Coal-measures that occurs partly within and partly outside this district. In descending the hill from Stony Houghton to the top of the valley, by the turnpike road, there is the following section. Top beds, coarse yellow limestone, getting very hard towards the bottom; below these grey fossiliferous limestone, the bottom part rubbly; below these red marls, and in the brook at the bottom of the hill there is some yellow sandstone, which must belong to the Coal-measures. In descending the Langwith Valley no good section is found in the bottom, and the rocks on the sides are yellow limetones, a little inclined to be sandy at their base in Langwith Wood. The dip of the beds is slightly eastward. The country between Langwith and Pleasley Vale consists entirely of yellow limestone, generally, where not much decomposed, of a hard and coarse grain.

Bolsover Moor Quarries.

The stone of these quarries, I have before stated, is precisely like that of the Mansfield Woodhouse quarries. Bolsover Moor

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is high ground, and the limestone beds there must be high up in the series. There is a considerable descent from these quarries to the hamlet of Whaley, and although the general dip of the strata is eastward, it is probable that there the beds are much lower in the series than at the quarries.

Cresswell Crags.

The following description is from page 84 of the Memoir by Professor Sedgwick:—

"Among the rocks forming the beautiful ravine called Cresswell Crags, are some fine dolomites; but they are irregularly bedded, are associated with compact, cellular, and earthy varieties, and have not been quarried. There are, however, some beds on the hill to the north-west of the ravine which have been used for building, and, except in colour, resemble those of Bolsover Moor. In passing into a solid state, some of these beds have penetrated each other; so that their separation is not represented by a plane superficies, but by a number of imperfectly crystalline points and protuberances, which give to the surfaces of the blocks an appearance resembling artificial rustic work. These natural surfaces have been occasionally used in ornamental architecture."

Creswell Crags form a deep ravine cut through limestone, the rocky sides rising in some parts to a height of fifty or sixty feet. There is no regular bedding, the rock being massive, jointed and with large fissures and caverns, some of the latter extending to a considerable depth. The stone is exceedingly hard and compactly grained, and of a light-yellowish brown colour. As these beds have a general inclination towards the east there is a considerable thickness of them in the ravine, so that the west end of it must be very close to the bottom of the series; and this inference is borne out by the marshy nature of the ground and by the springs.*

Summary of the Lower Magnesian Limestone.

The most remarkable circumstance connected with the Magnesian Limestone over this district is its constant change of character, the various kinds of strata being found to extend only over very limited areas. The white sandstones, though of considerable thickness, are only found in the Mansfield quarries; and although there is every reason to suppose they are near the bottom of the series, no beds like them occur elsewhere along the western outcrop of the Magnesian Limestone. Within a very short distance another set of beds appear to occupy the exact position of the white sandstones. These are the red sandstone, which are only found in a narrow strip of ground from the Rock Valley to Debdale Lane,

* In Creswell Crags are situated the caves in which Flint implements and Mammalian remains were discovered by the Rev. J. M. Mello; *Quart. Journ. Geol. Soc.* vol. xxxi., page 679.

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and at their outcrop in a deteriorated form in Pleasley Vale, and also in a few spots up the valley between Pleasley Rocks and Stony Houghton. It is true that along the western outcrop there are sometimes reddish sandy and calcareous beds, but these are thin, and in quality unlike the red sandstone of Mansfield. There is also that stone—so good in quality and so beautiful in colour—which is found in perfection only at Mansfield Woodhouse, and Bolsover. These formations must have been deposited in large lenticular masses; but the red and white sandstones are probably equivalent strata, excess of iron having changed the colour in certain localities.

Over the whole area it is exceedingly difficult to find out the true dip, or even in many cases to know to what part of the series certain beds belong—whether they are above or below certain other beds which occur about a mile distant. The thickness of the whole series is likewise very uncertain, there being no data to be depended on, but there can be no doubt that the thickness becomes greatly augmented in a northerly direction. It is probable that at Sutton-in-Ashfield, it is not more than forty feet thick, not including the shales. In the Mansfield quarries, beds between sixty and seventy feet thick are laid bare; and at Cresswell Crags the thickness may exceed one hundred feet, without counting any shales or marls that there may be below.

Permian Marls and Sandstone.

These consist of red marls and red and white sandstones *which overlie the Lower Magnesian Limestone somewhat unconformably*, that formation appearing to have been disturbed before the marls and sandstones were deposited over it. These marls and sandstones are opened out in several places for the purpose of brickmaking, both sand and marl being ground up together. Some of the brickyards are on the west and south sides of the outlier of New Red Sandstone and Permian Marls between Mansfield and Sutton-in-Ashfield, where the beds are deep-red clays, with thin bands of soft sandstone, either white or red, lying horizontal. Bricks, tiles, and draining pipes are made in these yards. Immediately under the marls there are beds of crystalline limestone.

Over one of the white freestone quarries at Mansfield there was formerly exposed, marls lying on limestone beds (as in the woodcut below), showing that there was not the slightest passage from the one into the other; and the undulating surface of the limestone may, perhaps, indicate that erosion took place before the disposition of the marls.

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Overlying these white sandstone quarries there is some thickness of red marl, and beds of from one inch to two feet in thickness of soft sandstone of a light colour; but these marls and sandstones have thinned away, or have been overlapped before the Rock-valley quarries are reached, for there only the Soft Red Bunter Sandstone is seen above the limestone, but the marls come on again farther north. The small outlier of marl west of Mansfield has been opened for brickmaking. Red marls are occasionally seen for a mile or two north of Mansfield Woodhouse. There is also an outlier of sandstone and marl west of Sookholm Chapel,* but these beds do not come on in any force till north of Cuckney, and there the beds of sandstone equal the beds of marl in thickness, if they do not exceed them. A good section of these sandstones may be seen in a lane between Woodhouse Hill Farm and Holbeck Woodhouse. Here there are between thirty and forty feet of soft red sandstone in thick beds, except about six feet at the centre, which consists of thin alternations of sandstone and marl. Another section may be seen in a road-cutting about ten chains to the south-east of Woodhouse Hill Farm, consisting of unconsolidated red sand containing a few pebbles, and interstratified with thin beds of more consolidated sand. The thickness of the sand is from twelve to fifteen feet. There are brick-yards in the marl north of Woodhouse Hall, and at the new gardens west of Welbeck Abbey red sandstones in hard flag-like beds have been quarried. The lake in Welbeck Park is on marl.

On the west side of Cresswell are two outliers, composed chiefly of red sand, and a section exposing the beds of the larger one may be seen in a cutting in a road leading from Lower Mill to Wood Lane. The sand occurs in beds, which are partially consolidated, and interstratified with thin beds of marl. The sand may be again seen in the pit at Broad Oak, where there is a small fault on the north side—a downthrow to the south. The sand has here so drifted over the limestone that it is impossible to get a correct boundary. The sands of the smaller outlier must lie on low beds of the Magnesian Limestone, some of which are also red.

Upper Magnesian Limestone.

This is a limestone that is found above the marls and sandstones, occurring in this district in two small outliers, on which the rock is nowhere well exposed; but farther to the north, in Yorkshire, is a thick and important formation.

On the larger of the two outliers the limestone has been quarried. This quarry has been filled up, but the fragments of the stone are strewn plentifully over the field. It is a fine and close-grained stone, of a yellow colour, and it appears from the fragments to be stratified in thin flag-like beds. No fossils were

* The new line of railway from Mansfield to Worksop has exposed in a cutting some red marl west of Langwith, they are probably brought in by the fault marked on the map. (May 1879.)

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seen in these scattered fragments, though they occur plentifully in the equivalent beds in the north. The existence of the smaller outlier is only indicated by the loose stones lying on the field.

NEW RED SANDSTONE SERIES.

The New Red Sandstone or Trias occupies nearly three-quarters of the area of this district.

Lower Soft, Red and Mottled Sandstone.

This formation is of no great thickness, and for the most part occupies the lower part of the slope that descends from the Forest Lands. It is, as its name implies, a red sandstone, semi-consolidated, and generally made of very fine grains. Some of it is so fine and free from earthy matters, that it furnishes a most excellent moulding-sand, for which purpose it has been dug on the side of the hill south-east of Mansfield. It also occurs equally good in a field north of Mansfield, and there are other places, no doubt, along its range, where it may be found of good quality. Another peculiarity of this sandstone is, that it is free (or nearly so) from the pebbles that characterize the formation overlying it.

Sections of the Soft Red Sandstone may be seen in many of the roads that lead from the low ground to the Forest Lands.

It will be observed that the New Red Sandstone overlaps the Permian Marls and Sandstones in many places. If all the beds were conformable the Upper Magnesian Limestone would come out from beneath the Soft Red Sandstone; but, beyond all doubt, there is a break between the New Red Sandstone and the Permian strata in this district.

The Lower Soft, Red and Mottled Sandstone passes gradually up into the next division of the Bunter beds.

Pebble Beds and Conglomerate.

These consist of beds of yellow, brown, and red sandstone, varying in structure from hard consolidated beds to loose sand. But their characteristic feature is the pebbles, which sometimes form a hard conglomerate and at others lie loosely mixed with the unconsolidated sand. The pebbles are of all sizes and derived from various older formations, and chiefly consist of quartz, white, red, green, and of other colours.

It will be seen by the map how large an area these beds occupy, —in fact the whole of the Forest Lands; and it is owing to its poor, sandy, and gravelly soil that the Forest of Sherwood existed so long, the greater part being still retained as woodland or common. Owing to the nature of this rock there are but few sections exposed, taking into account the extent of country it covers. This arises from its soft composition, so that instead of standing out sharply like the harder rocks, it is worn into rounded hills

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and buried in its own debris. Being useless for most purposes, there are also few artificial sections. It is only when a bed much harder than the rest sticks out on the side of some bank or deep road-cutting that we get a sight of these beds, and a person may wander for a long time over the Forest and see nothing but gravel and sand. There are two or three good sections on the side of the hill east of Mansfield, especially one showing the junction with the underlying soft red sandstone in the large pit which is worked for moulding sand. There is no difference in colour here between the two formations, only the lower has no pebbles and the sand is much finer,—for the sand of the Pebble Beds as a whole is coarse.

It must not be supposed that because these beds occupy such an extensive area when compared with the areas of the other formations, that they have a corresponding thickness. It is probable that when you have crossed its western or lower boundary, and rise to the highest point of the western escarpment, you have crossed its whole thickness, or nearly so; and if you walk from thence to its eastern or upper boundary, you may walk on the same bed all the way, or rather on repetitions of the same beds, as you cross the minor undulations of the country; for, as has been stated, the Forest Land has a general slope to the east, and the inclination of the strata is about the same as that slope, both in direction and amount.

Keuper Series.

The last described formation is succeeded in this locality by the Waterstones of the Keuper Series; but there is no passage from the one to the other, two formations being absent between them, namely, the Upper Mottled Sandstone of the Bunter, and the lower sandstones of the Keuper Series. I know of no good section in this district showing a clear junction of these formations, but districts both to the north and south there are junctions showing the Waterstones lying direct on the Pebble Beds, without the slightest indications of a passage from the one into the other.

The Waterstones consist of soft sandstones and red marls. At the bottom are some beds of light-coloured sandstones and bluish clay, which may be considered as a mere local variety, occurring in this district and a little to the north and south of it. These beds may be seen in the brick-yard south-west of Ollerton, and above these blue clays and sandstones come the usual beds, consisting of soft porous sandstones, brown, red, reddish-brown, and white. With these are interstratified beds of red marl, which is sometimes sandy. In brick-making both the marls and sandstones are ground up together. Sections of these beds may be seen in many of the road-cuttings.

The Waterstones gradually pass up into the ordinary New Red Marl, there being in fact no definite boundary between them. The soft sand stones which are so thick below, gradually become thinner and harder and the marls thicken, till the formation consists of red and variegated marls interstratified with beds of white sandstone,

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which are sometimes very hard. Sometimes the sandstones in the higher marls are thick enough to be used for building-stones. These sandstone beds are found more or less all through the Keuper Marls, but places where they occur very plentifully have been indicated on the map by a blue colour over the red. Some parts of these strata form ground as much as 303 feet above the level of the sea. The country is a good deal cut into valleys, but taking it as a whole it has a steep escarpment on the west and a gentle inclination to the east, in accordance with the dip of the beds.

DRIFT.

The Drift of this district is a deposit of gravel and sand spread over the other formations at a comparatively recent geological period. It has been derived from a great variety of rocks, both far and near, but the greater part of it appears to be made of the pebbles and sand of the Bunter Pebble Beds. The foreign pebbles composing this drift, are often found mixed with fragments or pebbles of the rock on which it lies, or if the formation below is marl, then they are mixed with a deposit of clay. Over the area where the Pebble Beds extend it is not easy to distinguish the recent superficial formation from the older deposit of sand and pebbles, for on the surface they are generally mixed together.

It is not in many places over this district that the Drift is so thick as to prevent our arriving at some conclusion with regard to the nature of the underlying strata; but it often renders for some distance the tracing of the boundary-line between two formations very difficult, and unsatisfactory. On some of the hills of Keuper Marl the Drift lies very thick, as on Kneesall Hill, where there are from twenty to thirty feet of it; but it is only in patches that it lies so thickly.

When Drift is thickly spread over a limestone or a marl the character of the soil is different to what it would be if the native rock lay close to the surface; for instead of the wet clay soil natural to the marls, there would naturally be a gravelly and sandy soil; but over the Pebble Beds the presence of Drift makes but slight difference in the nature of the soil.

PHYSICAL GEOGRAPHY.

If a person were to traverse this district from west to east with the geological map in his hand he would be at once struck with the changes the aspect of the country undergoes as he crosses those parts which are represented by different colours. He would then see that the colours in question not only represent the different geological formations, but, on a great scale, the physical features of the country; and that it is the geological formations and the changes they have undergone that have given to the country its present features.

There is, first, the country over which the Magnesian Limestone is spread, with its low hills and deeply-cut rocky valleys,

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and its light arable soil, or stony ground, where the soil is thin. When the eastern boundary of the Limestone is crossed, you ascend the escarpment of the Lower Soft Red and Mottled Sandstone, with its steep and smooth outline. After crossing the lower boundary of the Pebble Beds the summit of the hill is reached, and you have before you a very different country to that you have left, in the now half-cultivated Forest of Sherwood, which, most probably, would not have remained a forest so long, if it had not been for that extensive deposit of sand and pebbles that extends from Nottingham far away towards the north. It is only of late years that any of this land has been enclosed and brought under cultivation; much of it is still in its natural wild state, either covered with forest-trees or gorse, or remaining in the state of open land, and, the soil being so light and sandy, it will never, probably, be highly cultivated. Most of the ground on the western borders of this Forest Land ranges in height from 300 to near 650 feet above the level of the sea, and is only broken by the rivers that flow through it from west to east. The ground, as has been before stated, descends gradually towards the east, the descent being interrupted only by minor undulations. On crossing the upper and eastern boundary of the Pebble Beds we leave the sandy and Forest-lands, and come upon a rich soil and cultivated tract of country, and begin to ascend the high ground capped by the New Red (Keuper) Marls. These hills of soft red marl vary in height between 200 and 300 feet above the level of the sea, and they have their steeper slopes to the west and their gentler inclinations towards the east; but these last are much cut up by numerous small valleys, the brooks in which have their sources chiefly near the tops of the hills and flow eastward. None of the rivers that flow through the Forest penetrate the clays; but, on reaching the low ground on the east side of the Forest, they flow away to the north, finding their way by easier channels than through the tough marls of the Keuper Series.

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LONDON:
Printed by GEORGE E. EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.
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COAL-FIELDS OF UNITED KINGDOM.

(Illustrated by the following Maps.)

Anglesey, 78 (SW).
Bristol and Somerset, 19, 35.
Coalbrook Dale, 61 (NE & SE).
Clee Hill, 53 (NE, NW).
Denbighshire, 74 (NE & SE), 79 (SE).
Derby and Yorkshire, 71 (NW, NE, & SE), 82 (NW & SW), 81 (NE), 87 (NE, SE), 88 (SE)
Durham, 105.
Flintshire, 79 (NE & SE).
Forest of Dean, 43 (SE & SW).
Forest of Wyre, 61 (SE), 55 (NE).
*Lancashire, 80 (NW), 81 (NW), 89 (SE, NE, NW, & SW), 88 (SW). (For corresponding six-inch Maps, see detailed list.)
*Leicestershire, 71 (SW), 63 (NW).
Northumberland and Durham (N. part), 105 (NE & SE).
*North Staffordshire, 72 (NW), 72 (SW), 73 (NE), 80 (SE), 81 (SW).
*South Staffordshire, 54 (NW), 62 (SW).
Shrewsbury, 60 (NE), 61 (NW & SW).
South Wales, 36, 37, 38, 40, 41, 42 (SE, SW).
*Warwickshire, 62 (NE & SE), 63 (NW & SW), 54 (NE), 53 (NW).
Yorkshire, 88, 87 (SW), 93 (SW), &c.

SCOTLAND.

*Edinburgh, 32, 33. *Haddington, 32, 33.
Fife and Kinross, 40, 41., &c. &c.

IRELAND.

*Kanturk, 174, 175. *Castlecomer, 128, 137.
*Killenaule (Tipperary), 146.
(For Sections illustrating these Maps, see detailed list.)
* With descriptive Memoir.

GEOLOGICAL MAPS.

Scale, six inches to a mile.

The Coalfields of Lancashire, Northumberland, Cumberland, Westmorland, Durham, Yorkshire, Edinburghshire, Haddington, Fifeshire, Renfrewshire, Dumbartonshire, Dumfriesshire, Lanarkshire, Stirlingshire, and Ayrshire are surveyed on a scale of six inches to a mile.

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56. Haggate. 6s.
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62. Balderstone, &c.
63. Accrington.
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94. West Houghton, Hindley, Atherton
95. Radcliffe, Peel Swinton, &c.
96. Middleton, Prestwich, &c.
97. Oldham, &c.
100. Knowsley, Rainford, &c.
101. Billinge, Ashton, &c.
102. Leigh, Lowton.
103. Ashley, Eccles.
104. Manchester, Salford, &c.
105. Ashton-under-Lyne.
106. Liverpool, &c.
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Durham—cont.

Sheet.
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17. Waskerley.
18. Muggleswick.
19. Lanchester. 6s. Vertical Section, 39.
20. Hetton-le-Hole.
24. Stanhope.
25. Wolsingham.
26. Brancepeth.
32. White Kirkley.
33. Hamsterley.
34. Whitworth.
41. Cockfield.
42. Bishop Auckland.

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65. Newbiggin. 4s.
68. Belingham.
69. Redesdale.
72. Bedlington.
73. Blyth. 4s.
77. Swinburn.
78. Ingoe. 6s.
80. Cramlington.
81. Earsdon.
84. Newborough.
85. Chollerton.
86. Matfen.
87. Heddon-on-the-Wall.
88. Long Benton.
89. Tynemouth.
92. Haltwhistle.
95. Corbridge.
96. Horsley. 4s.
97. Newcastle-on-Tyne. 4s.
98. Walker. 4s.
101. ———
102. Allendale Town.
105. Newlands.
107. Allendale.
108. Blanchland.
109. Shotleyfield.
110. Wellhope.
111. Allenheads.

Yorkshire.

100. Limley.
184. Kelbrook.
201. Bingley.
204. Aberford.
216. Bradford.
217. Calverley.
218. Leeds.
219. Kippax.
231. Halifax.
232. Birstal.
233. East Ardsley.
234. Castleford.
246. Huddersfield.
260. Honley.
272. Holmfirth.
273. Penistone.
274. Barnsley.
275. Darfield.
276. Brodsworth.
281. Langsell.
282. Wortley.
283. Wath upon Dearne.
284. Conisborough.
287. Low Bradford.
288. Ecclesfield.
289. Rotherham.
290. Braithwell.
293. Hallam Moors. 4s.
295. Handsworth.
296. Laughton-en-le-Morthen.
299. ———.
300. Harthill.

SCOTLAND.

Scale, six inches to a mile.

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7. Dalkeith, &c.
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32. Dysart, &c.
33. Buckhaven.
35. Dunfermline.
36. Kinghorn.
37. Kinghorn. 4s.

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Six inches to one mile.

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28. Tarbolton, &c.
30. Aird's Moss.
31. Muirkirk. 4s.
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36. Grieve Hill.
40. Chiltree.
41. Dalleagler.
42. New Cumnock.
46. Dalmellington.
47. Benbeock.
50. Daily.
52. Glenmoat.

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